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Jung et al.

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(54) **APPARATUS AND METHOD FOR DETECTING FOREIGN OBJECTS IN WIRELESS POWER TRANSMISSION SYSTEM**

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H02J 5/00 (2016.01)
H02J 3/06 (2006.01)

(52) **U.S. Cl.**

CPC ***H02J 17/00*** (2013.01); ***H02J 5/005*** (2013.01)

(58) **Field of Classification Search**

CPC H02J 3/06
USPC 307/104
See application file for complete search history.

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* cited by examiner

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(57) **ABSTRACT**

Aspects of the present invention relate to an apparatus and method for detecting foreign objects in a wireless power transmission system. This specification provides a wireless power reception apparatus for detecting foreign objects, including a power measurement unit for generating required power information indicative of required power for the wireless power reception apparatus, sending the required power information to a wireless power transmission apparatus, and measuring power induced from the wireless power transmission apparatus and a secondary coil for receiving the power induced from the wireless power transmission apparatus. In accordance with the present invention, foreign objects intervened between the wireless power transmission apparatus and the wireless power reception apparatus are recognized, and a user removes the foreign objects. Accordingly, damage to a device attributable to foreign objects can be prevented.

16 Claims, 9 Drawing Sheets

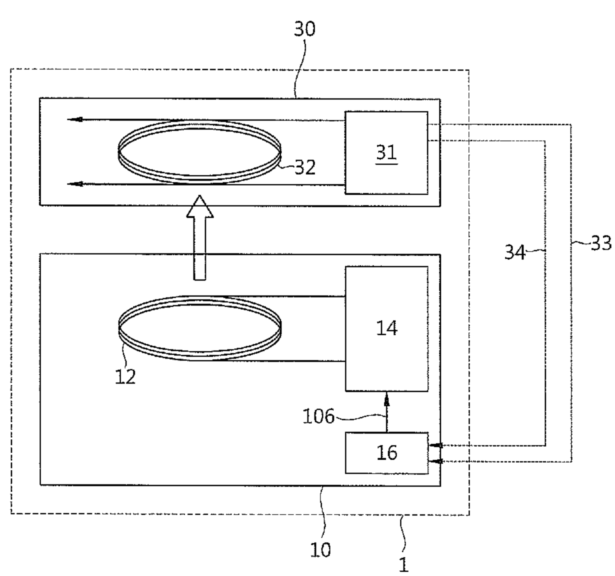


FIG. 1

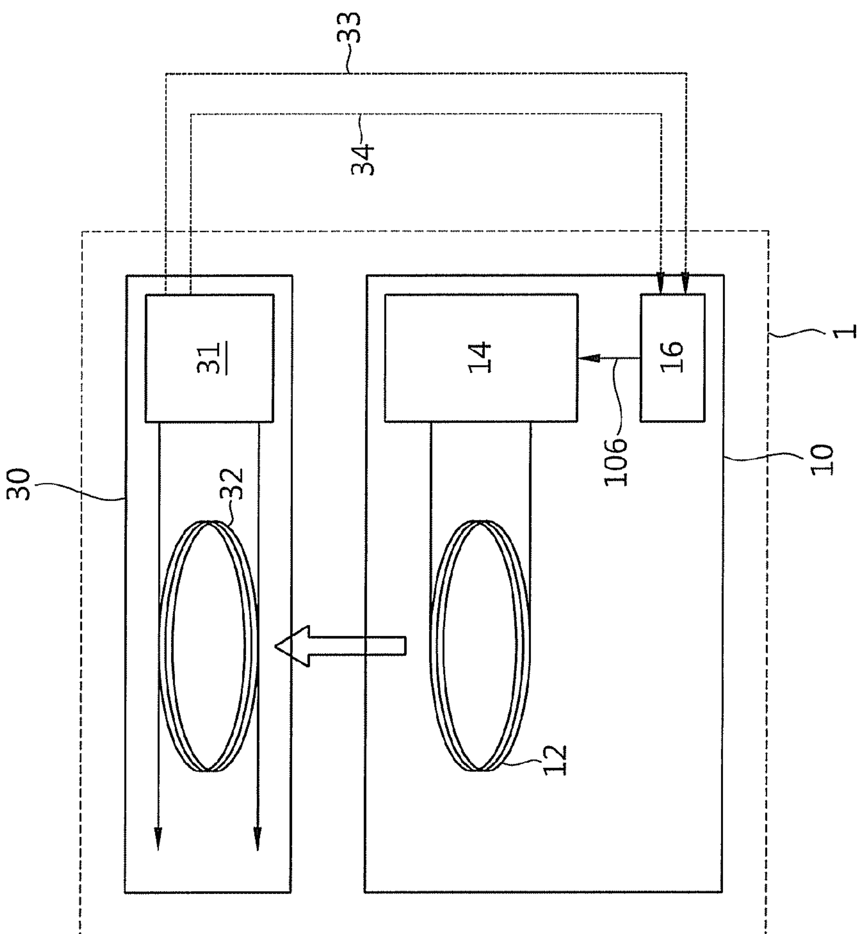


FIG. 2

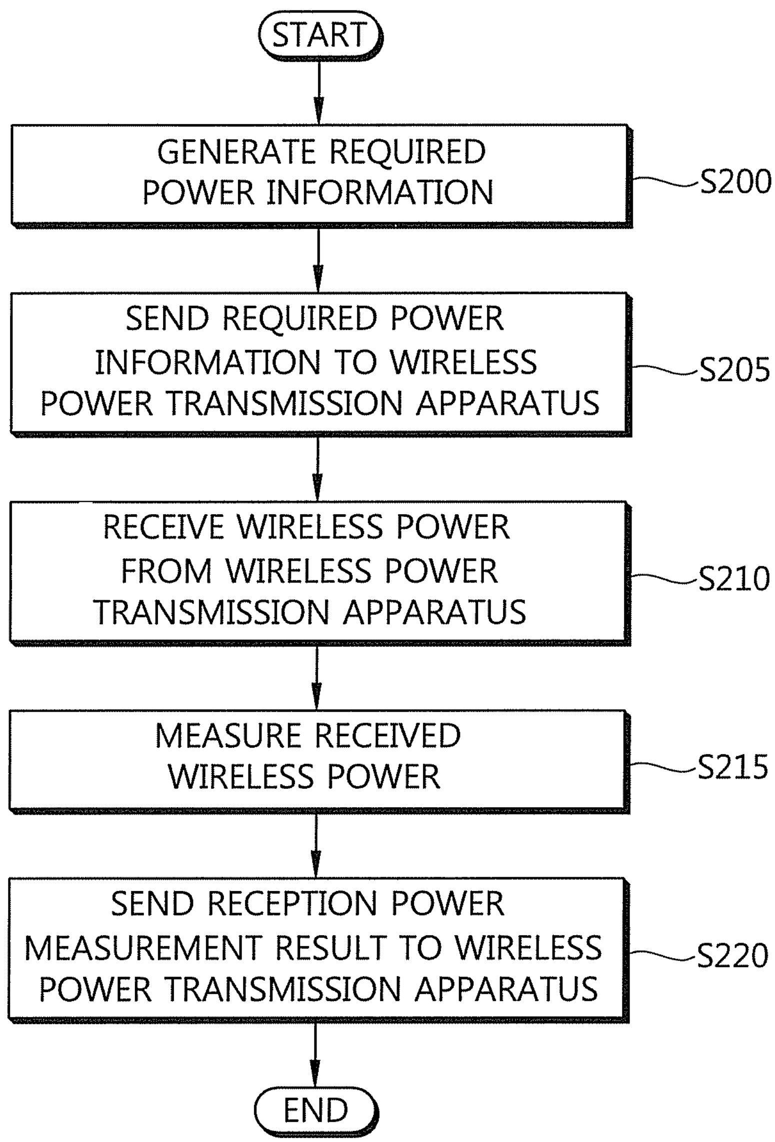

START
GENERATE REQUIRED POWER INFORMATION
S200
SEND REQUIRED POWER INFORMATION TO WIRELESS POWER TRANSMISSION APPARATUS
S205
RECEIVE WIRELESS POWER FROM WIRELESS POWER TRANSMISSION APPARATUS
S210
MEASURE RECEIVED WIRELESS POWER
S215
SEND RECEPTION POWER MEASUREMENT RESULT TO WIRELESS POWER TRANSMISSION APPARATUS
S220
END

FIG. 3

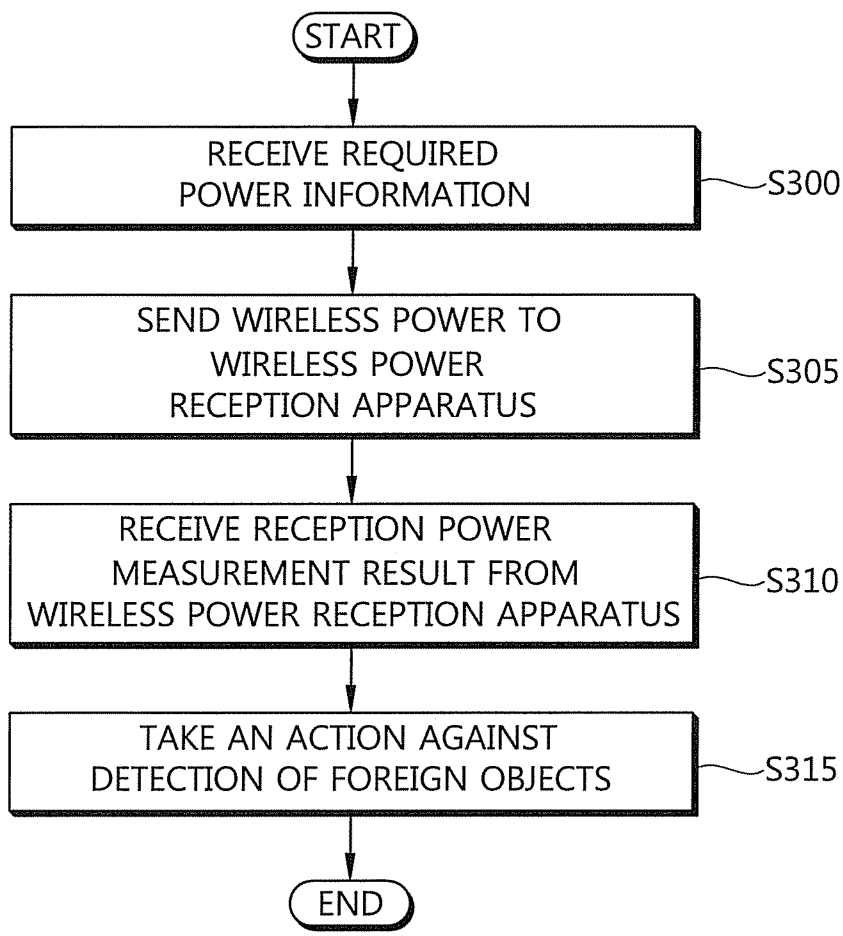

START
RECEIVE REQUIRED POWER INFORMATION
S300
SEND WIRELESS POWER TO WIRELESS POWER RECEPTION APPARATUS
S305
RECEIVE RECEPTION POWER MEASUREMENT RESULT FROM WIRELESS POWER RECEPTION APPARATUS
S310
TAKE AN ACTION AGAINST DETECTION OF FOREIGN OBJECTS
S315
END

FIG. 4

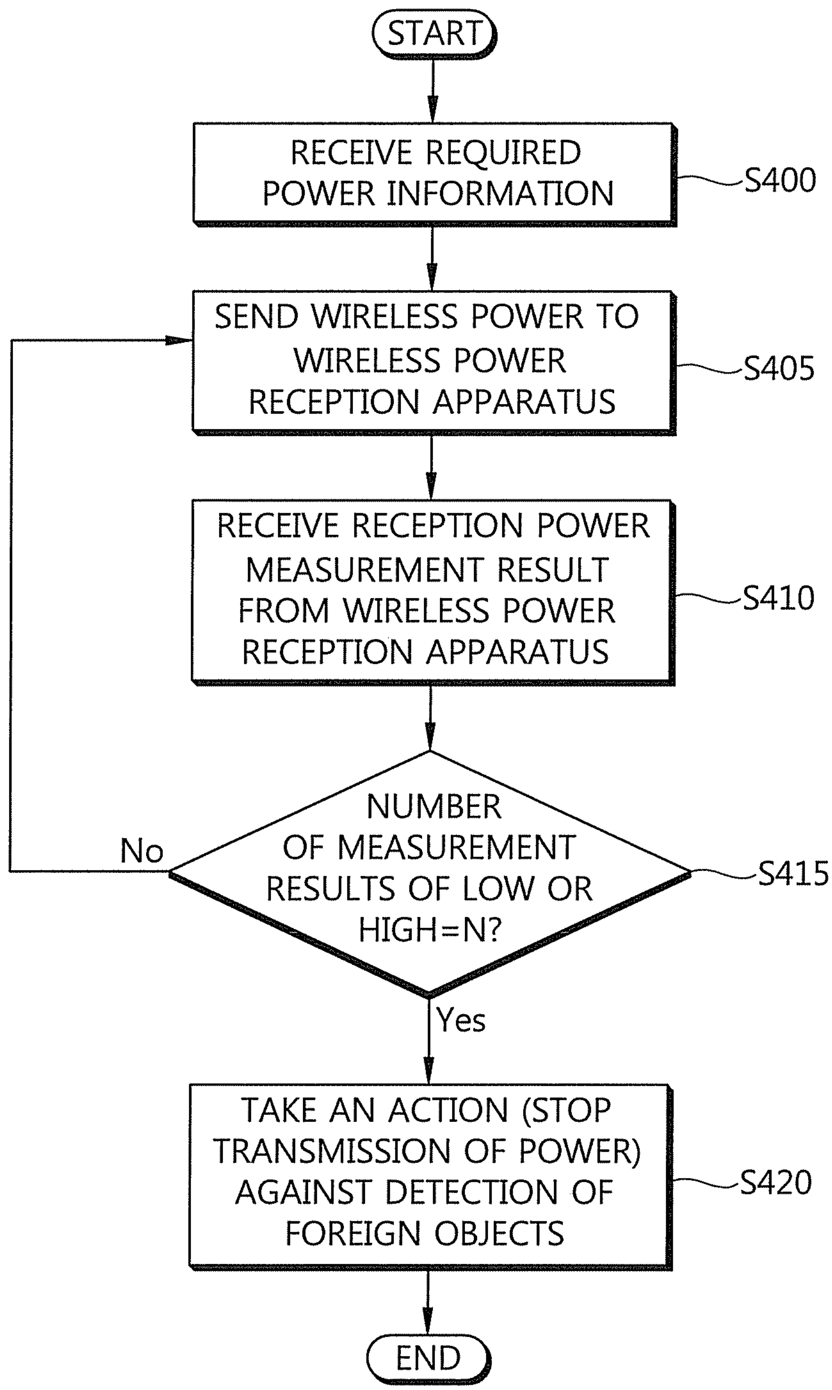

START
RECEIVE REQUIRED POWER INFORMATION
S400
SEND WIRELESS POWER TO WIRELESS POWER RECEPTION APPARATUS
S405
RECEIVE RECEPTION POWER MEASUREMENT RESULT FROM WIRELESS POWER RECEPTION APPARATUS
S410
NUMBER OF MEASUREMENT RESULTS OF LOW OR HIGH=N?
S415
No
Yes
TAKE AN ACTION (STOP TRANSMISSION OF POWER) AGAINST DETECTION OF FOREIGN OBJECTS
S420
END

FIG. 5

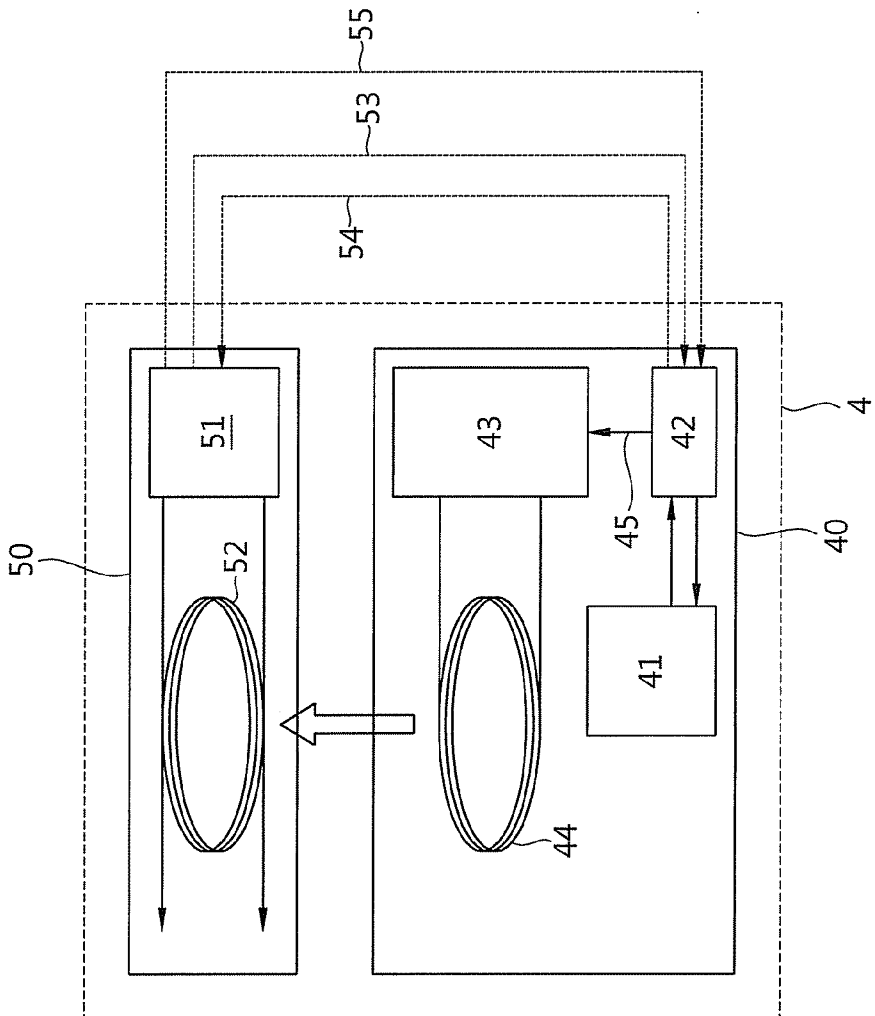


FIG. 6

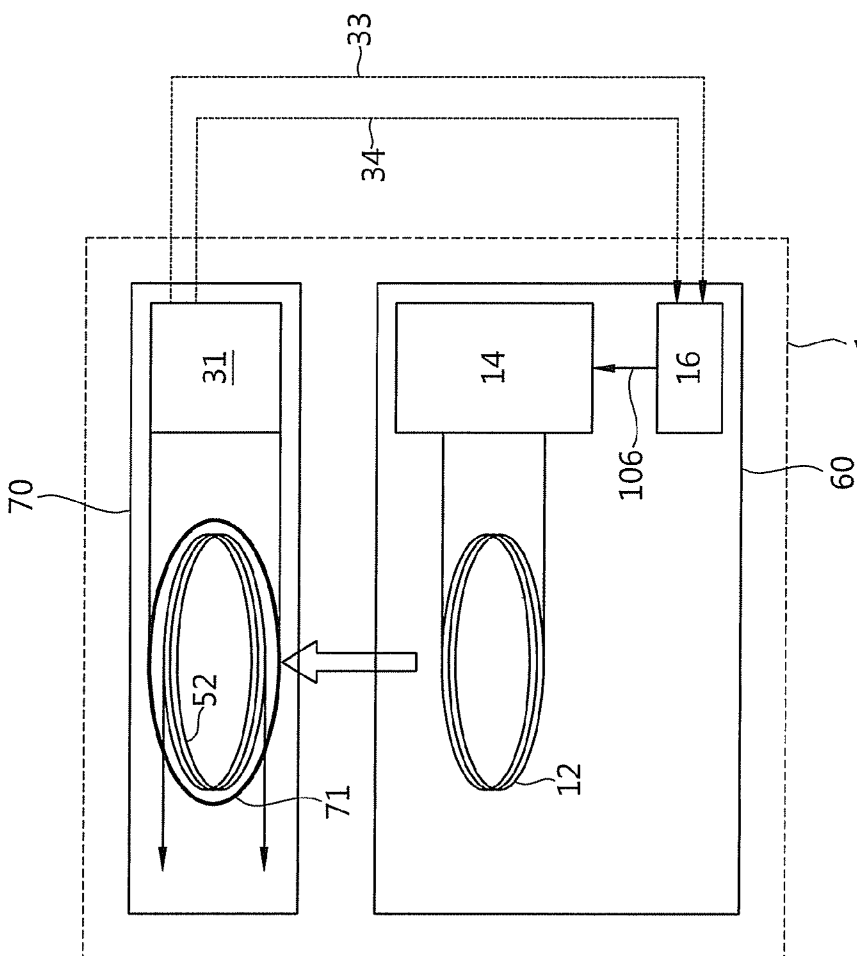


FIG. 7

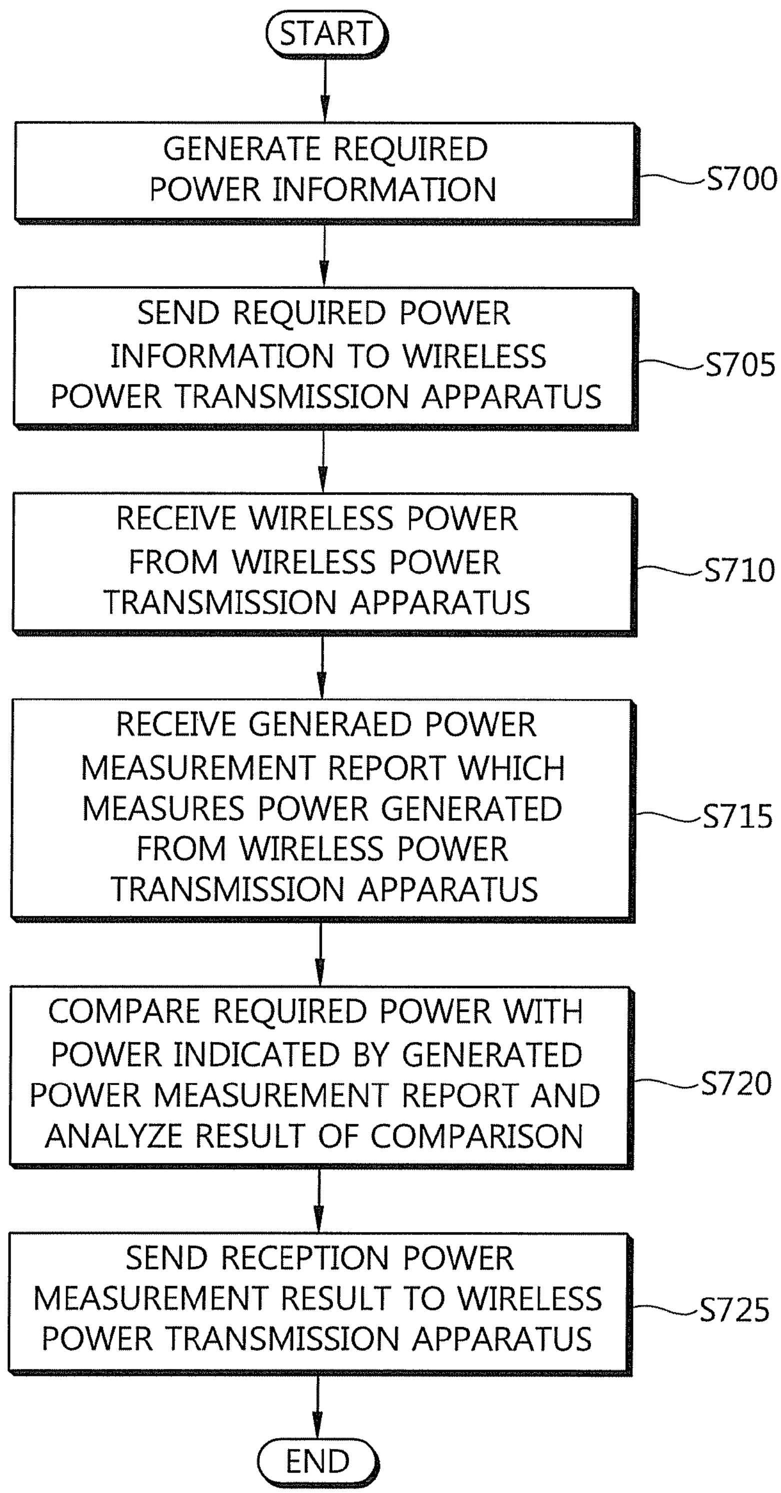

START
GENERATE REQUIRED POWER INFORMATION
S700
SEND REQUIRED POWER INFORMATION TO WIRELESS POWER TRANSMISSION APPARATUS
S705
RECEIVE WIRELESS POWER FROM WIRELESS POWER TRANSMISSION APPARATUS
S710
RECEIVE GENERAED POWER MEASUREMENT REPORT WHICH MEASURES POWER GENERATED FROM WIRELESS POWER TRANSMISSION APPARATUS
S715
COMPARE REQUIRED POWER WITH POWER INDICATED BY GENERATED POWER MEASUREMENT REPORT AND ANALYZE RESULT OF COMPARISON
S720
SEND RECEPTION POWER MEASUREMENT RESULT TO WIRELESS POWER TRANSMISSION APPARATUS
S725
END

FIG. 8

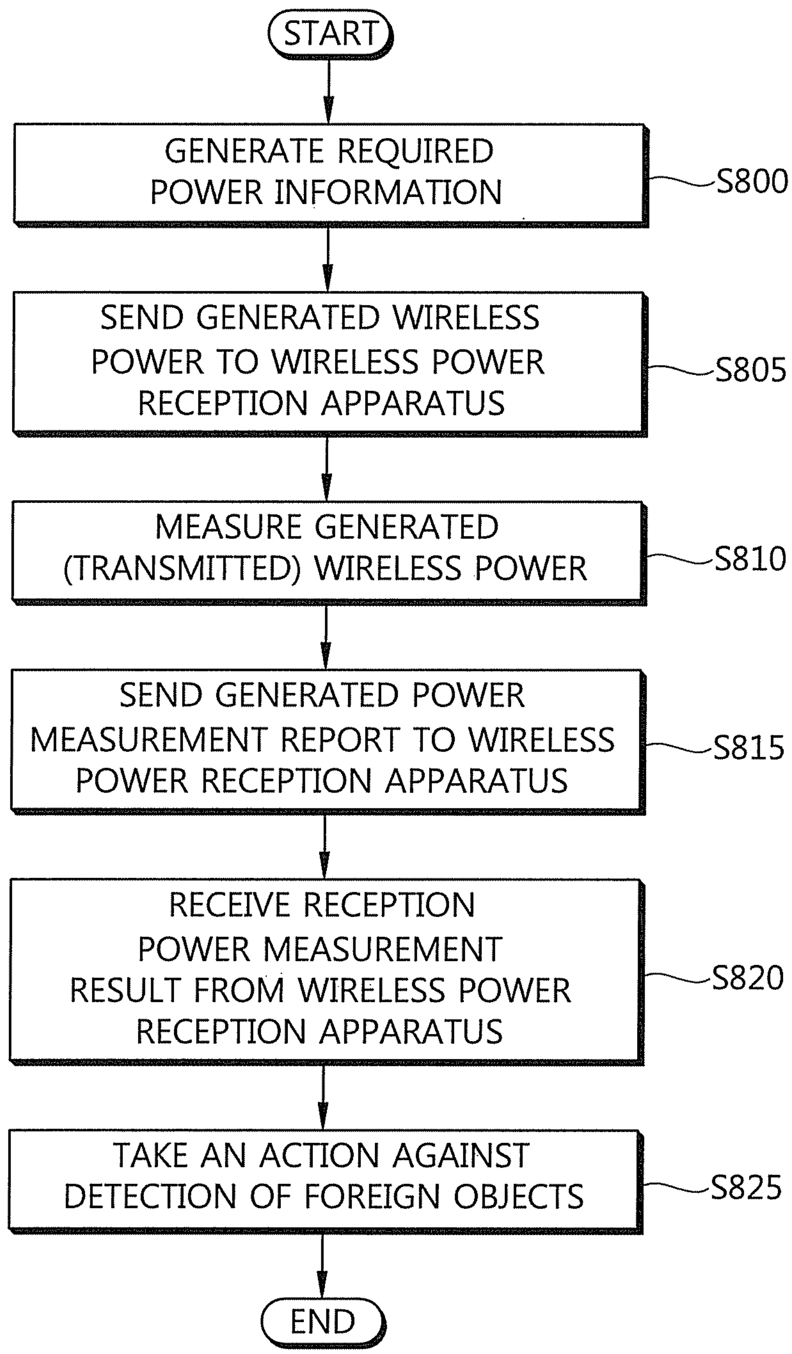
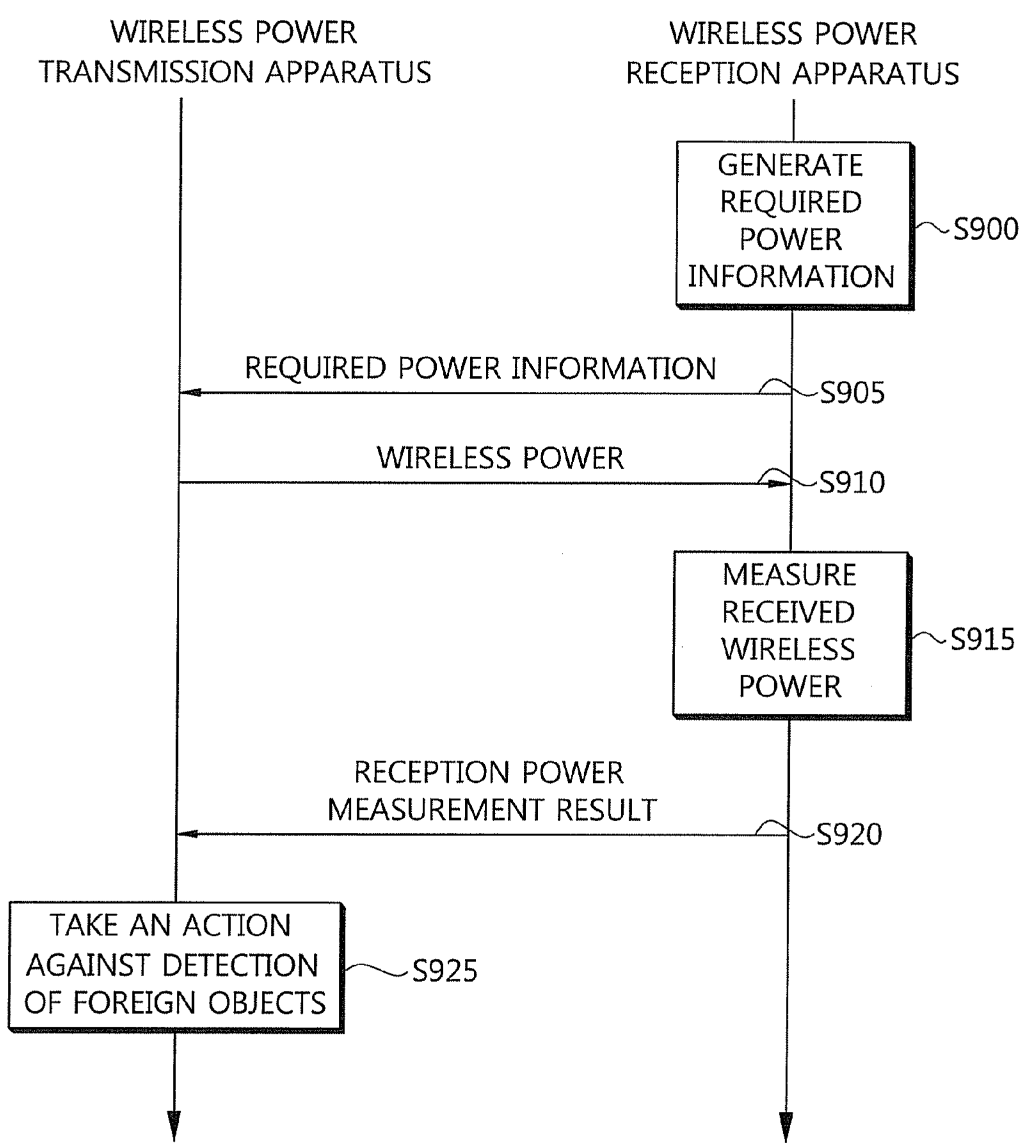

START
GENERATE REQUIRED POWER INFORMATION
S800
SEND GENERATED WIRELESS POWER TO WIRELESS POWER RECEPTION APPARATUS
S805
MEASURE GENERATED (TRANSMITTED) WIRELESS POWER
S810
SEND GENERATED POWER MEASUREMENT REPORT TO WIRELESS POWER RECEPTION APPARATUS
S815
RECEIVE RECEPTION POWER MEASUREMENT RESULT FROM WIRELESS POWER RECEPTION APPARATUS
S820
TAKE AN ACTION AGAINST DETECTION OF FOREIGN OBJECTS
S825
END

FIG. 9


WIRELESS POWER TRANSMISSION APPARATUS
WIRELESS POWER RECEPTION APPARATUS
GENERATE REQUIRED POWER INFORMATION
S900
REQUIRED POWER INFORMATION
S905
WIRELESS POWER
S910
MEASURE RECEIVED WIRELESS POWER
S915
RECEPTION POWER MEASUREMENT RESULT
S920
TAKE AN ACTION AGAINST DETECTION OF FOREIGN OBJECTS
S925

APPARATUS AND METHOD FOR DETECTING FOREIGN OBJECTS IN WIRELESS POWER TRANSMISSION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. patent application Ser. No. 13/939,035, filed Jul. 10, 2013, which claims the benefit of Korean Application No. 10-2012-0075276, filed Jul. 10, 2012, in the Korean Intellectual Property Office. All disclosures of the document named above are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Aspects of the present invention relate to the transmission of wireless power and, more particularly, to an apparatus and method for detecting foreign objects in a wireless power transmission system.

2. Description of the Related Art

In general, a battery pack functions to receive electric power (electrical energy) from an external charger and supply a power source for driving a portable terminal (e.g., a mobile phone or a PDA) in a charging state. The battery pack includes a battery cell for charging the electrical energy, a circuit for charging or discharging the battery cell (i.e., supply the electrical energy to the portable terminal), etc.

An electrical coupling method for coupling the battery pack and the charger for charging the battery pack used in this portable terminal with the electrical energy source includes a terminal supply method for receiving a commercial power source, converting the commercial power source into voltage and current corresponding to the battery pack, and supplying electrical energy to the battery pack through the terminal of the battery pack.

However, the terminal supply method has problems, such as an instant discharge phenomenon due to a potential difference between terminals, damage and the occurrence of a fire due to foreign objects, natural discharge, and a reduction in the lifespan and performance of a battery pack.

In order to solve the problems, contactless type charging systems and control methods using a wireless power transmission method are being recently proposed.

The contactless type charging system includes a contactless power transmission apparatus for supplying electrical energy according to a wireless power transmission method, a contactless power reception apparatus for receiving the electrical energy from the contactless power transmission apparatus, and charging a battery cell with the electrical energy, etc.

Meanwhile, in the contactless type charging system, the contactless power reception apparatus is charged in the state in which it is placed in the contactless power transmission apparatus owing to the characteristics of the contactless method.

Here, if foreign objects, such as metal, are placed in the contactless power transmission apparatus, the transmission of the wireless power is not smoothly performed due to the foreign objects and there is a problem in that a product is damaged due to an overload.

SUMMARY OF THE INVENTION

An object of the present invention provides an apparatus and method for detecting foreign objects in a wireless power transmission system.

In accordance with an aspect of the present invention, there is provided a wireless power reception apparatus for detecting foreign objects. The apparatus includes a secondary coil magnetically or resonantly coupled with a primary coil included in a wireless power transmission apparatus and configured to receive wireless power and a power measurement unit configured to generate required power information indicative of a power required by the wireless power reception apparatus, send the required power information to the wireless power transmission apparatus, and measure the received wireless power.

The power measurement unit may configure a reception power measurement result obtained by comparing the required power with the measured wireless power and send the reception power measurement result to the wireless power transmission apparatus.

In accordance with another aspect of the present invention, there is provided a wireless power reception apparatus for detecting foreign objects. The apparatus includes a secondary coil coupled with a primary coil included in a wireless power transmission apparatus and configured to receive wireless power and a power measurement unit configured to generate required power information indicative of required power necessary for wireless charging, receive a generated power measurement report indicative of wireless power generated from the wireless power transmission apparatus from the wireless power transmission apparatus, configure a reception power measurement result obtained by comparing the required power with the generated wireless power and analyzing a result of the comparison, and send the required power information and the reception power measurement result to the wireless power transmission apparatus.

In accordance with yet another aspect of the present invention, there is provided a wireless power reception method of a wireless power reception apparatus detecting foreign objects. The method includes generating required power information indicative of required power for wireless charging, sending the required power information to a wireless power transmission apparatus, receiving wireless power using a secondary coil coupled with a primary coil included in the wireless power transmission apparatus, measuring the received wireless power, configuring a reception power measurement result obtained by comparing the required power with the measured wireless power and analyzing a result of the comparison, and sending the reception power measurement result to the wireless power transmission apparatus.

In accordance with yet another aspect of the present invention, there is provided a wireless power transmission apparatus for detecting foreign objects. The apparatus includes a control unit configured to receive required power information, indicative of required power necessary to charge a wireless power reception apparatus from the wireless power reception apparatus, generate a control signal for providing the required power, and send the control signal to an electricity driving unit, the electricity driving unit configured to apply an electricity driving signal to a primary coil in response to the control signal, and a primary coil coupled with the electricity driving unit, coupled with a secondary coil included in the wireless power reception apparatus, and configured to send wireless power.

The control unit may receive a reception power measurement result, obtained by comparing wireless power measured by the wireless power reception apparatus with the required power, from the wireless power reception apparatus.

In accordance with yet another aspect of the present invention, there is provided a wireless power transmission apparatus for detecting foreign objects. The apparatus includes a control unit configured to receive required power information indicative of required power necessary to charge a wireless power reception apparatus from the wireless power reception apparatus, generate a control signal for providing the required power, and send the control signal to an electricity driving unit, the electricity driving unit configured to apply an electricity driving signal to a primary coil in response to the control signal, a primary coil coupled with the electricity driving unit, coupled with a secondary coil included in the wireless power reception apparatus, and configured to send wireless power, and a power measurement unit configured to measure wireless power generated from the primary coil.

The control unit may configure a generated power measurement report indicative of the generated wireless power, send the generated power measurement report to the wireless power reception apparatus, and receive a reception power measurement result, obtained by comparing the generated wireless power with the required power and analyzing a result of the comparison, from the wireless power reception apparatus.

In accordance with yet another aspect of the present invention, there is provided a wireless power transmission method of a wireless power transmission apparatus detecting foreign objects. The method includes receiving required power information indicative of required power necessary to charge a wireless power reception apparatus from the wireless power reception apparatus, generating a control signal for providing the required power and applying an electricity driving signal to a primary coil included in the wireless power transmission apparatus, sending wireless power, generated from the primary coil in response to the electricity driving signal, to the wireless power reception apparatus including a secondary coil coupled with the primary coil, and receiving a reception power measurement result, obtained by comparing wireless power measured by the wireless power reception apparatus with the required power and analyzing a result of the comparison, from the wireless power reception apparatus.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings, of which:

FIG. **1** illustrates the elements of a wireless power transmission system in accordance with an example of the present invention;

FIG. **2** illustrates an example of a method by which a wireless power reception apparatus using the present invention detects foreign objects;

FIG. **3** illustrates an example of a method by which a wireless power transmission apparatus using the present invention detects foreign objects;

FIG. **4** illustrates another example of a method by which the wireless power transmission apparatus using the present invention detects foreign objects;

FIG. **5** illustrates the elements of a wireless power transmission system in accordance with another example of the present invention;

FIG. **6** illustrates the elements of a wireless power transmission system in accordance with yet another example of the present invention;

FIG. **7** illustrates another example of a method by which a wireless power reception apparatus using the present invention detects foreign objects;

FIG. **8** illustrates another example of a method by which a wireless power transmission apparatus using the present invention detects foreign objects; and

FIG. **9** is a flowchart illustrating the operation of the wireless power transmission apparatus and the wireless power reception apparatus using the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings so that they can be readily implemented by those skilled in the art. A term 'wireless power' used herein means energy having a specific form which is related to an electric field, a magnetic field, or an electromagnetic field transmitted from a transmitter to a receiver without using physical electromagnetic conductors. The wireless power may also be called a power signal and may mean an oscillating magnetic flux enclosed by a primary coil and a secondary coil. For example, the conversion of power in a system in order to wirelessly charge a device, such as a mobile phone, a cordless telephone, iPod®, an MP3® player, and a headset, is described herein. In general, a basic transfer principle of wireless energy includes, for example, both a magnetic induction coupling method and a magnetic resonance coupling (i.e., resonant induction) method using frequencies less than 30 MHz. However, various types of frequencies including frequencies in which a license-free operation in relatively high radiation levels, for example, less than 135 kHz (LF) or 13.56 MHz (HF) is permitted may be used.

FIG. **1** illustrates the elements of a wireless power transmission system in accordance with an example of the present invention.

Referring to FIG. **1**, the wireless power transmission system **1** includes a wireless power transmission apparatus **10** and at least one wireless power reception apparatus **30**. The wireless power transmission apparatus **10** includes a primary coil **12** and an electricity driving unit **14** coupled with the primary coil **12** and configured to supply electricity driving signals to the primary coil **12** in order to generate an electromagnetic field. A control unit **16** is coupled with the electricity driving unit **14**. The control unit **16** generates a control signal **106** that controls an AC signal necessary when the primary coil **12** generates an inductive magnetic field.

The wireless power transmission apparatus **10** can have a specific and proper form, and an exemplary form of the wireless power transmission apparatus **10** is a platform having a power transmission surface. A wireless power reception apparatus **30** can be placed on or near the platform.

The wireless power reception apparatus **30** can be separate from the wireless power transmission apparatus **10**. The wireless power reception apparatus **30** includes a secondary coil **32** coupled with an electromagnetic field generated from the wireless power transmission apparatus **10** when the wireless power reception apparatus **30** is placed near the wireless power transmission apparatus **10**. In this method, electric power can be transmitted from the wireless power transmission apparatus **10** to the wireless power reception apparatus **30** without a direct electrical contact. At this time, it is said that the primary coil **12** and the secondary coil **32** have been mutually subjected to magnetic induction coupling or resonant induction coupling.

The primary coil **12** and the secondary coil **32** can have specific and proper forms. Each of the primary coil **12** and the secondary coil **32** can be a copper wire on which high permeable magnetic materials, such as ferrite or amorphous metal, are surrounded. The secondary coil **32** may have a single core form or a dual coil form. Or, the secondary coil **32** may include two or more coils.

In general, the wireless power reception apparatus **30** is coupled with an external load (not shown) (here, the external load is also called the actual load of the wireless power reception apparatus) and configured to supply wireless power, received from the wireless power transmission apparatus **10**, to the external load. The wireless power reception apparatus **30** can be delivered to an object requiring electric power, such as a portable electrical or electronic device, a rechargeable battery, or a cell.

The wireless power reception apparatus **30** of the wireless power transmission system **1** of FIG. **1** further includes a power measurement unit **31** coupled with the secondary coil **32**.

The power measurement unit **31** generates required power information **33** indicative of power required or requested by the wireless power reception apparatus **30** and sends the required power information **33** to the control unit **16**. The required power information **33** is control information for controlling wireless power to be supplied to the wireless power reception apparatus **30**. The wireless power transmission system **1** of FIG. **1** supports a unidirectional communication method by which control information is transmitted along a path from the wireless power reception apparatus **30** to the wireless power transmission apparatus **10**.

For example, the required power information **33** can numerically indicate the amount of power required by the wireless power reception apparatus **30**. For example, if the wireless power reception apparatus **30** needs electric power of 10 W, the power measurement unit **31** can generate the required power information **33** indicative of 10 W.

The control unit **16** checks the required power information **33** and generates the control signal **106** so that electric power indicated by the required power information **33** is generated. For example, when the required power information **33** indicates 10 W, the control unit **16** generates the control signal **106** so that electric power of 10 W is transmitted. The electricity driving unit **14** receives the control signal **106** and converts the received control signal **106** into an AC signal in the primary coil **12** in order to generate an induction or resonant magnetic field near the primary coil **12**.

The power measurement unit **31** measures wireless power (or received wireless power) that is transferred from the primary coil **12** to the secondary coil **32** in response to the AC signal. The wireless power measured by the power measurement unit **31** can be calculated based on a difference between wireless power, transferred from the primary coil **12** to the secondary coil **32**, and other losses due to foreign objects, such as a parasitic load near the wireless power transmission system **1**.

For example, it is assumed that wireless power of 10 W is generated from the primary coil **12** in response to the required power information **33** and then transferred to the secondary coil **32** and power of 2 W is lost due to foreign objects. Here, power actually transferred to the secondary coil **32** (i.e., power actually received by the secondary coil **32**) is 8 W. The power actually received by the secondary coil **32** is called received power, and the received power is the total amount of power dissipated within the wireless power reception apparatus **30** due to a magnetic field generated from the wireless power transmission apparatus.

The power measurement unit **31** sends or provides a reception power measurement result **34**, reporting the results of measurement power obtained by comparing required power with measured (or actually received) power and analyzing the comparison result, to the control unit **16**.

In an embodiment, the power measurement unit **31** can indicate a difference between required power and measured power as the reception power measurement result **34**. In this case, the reception power measurement result **34** indicates 2 W.

In another embodiment, the power measurement unit **31** can indicate a measured power value itself as the reception power measurement result **34**. In this case, the reception power measurement result **34** indicates 8 W.

In yet another embodiment, the power measurement unit **31** can indicate a flag form (0 or 1), indicating whether there is a difference between required power and measured power or not, as the reception power measurement result **34**. For example, if there is no difference between the required power and the measured power, a flag is set to 1 (i.e., flag=1). If there is a difference between the required power and the measured power, a flag is set to 0 (i.e., flag=0), and the vice versa. In the above example, the reception power measurement result **34** indicates 1.

In yet another embodiment, the power measurement unit **31** can determine whether a difference between required power and measured power is greater than or equal to or smaller than a threshold value and indicate a result of the determination as the reception power measurement result **34**. For example, if a difference between the required power and the measured power is greater than the threshold value, the reception power measurement result **34** can be set to 1. If a difference between the required power and the measured power is smaller than or equal to the threshold value, the reception power measurement result **34** can be set to 0. In the above example, if the threshold value is 1 W, the reception power measurement result **34** indicates 1 because lost power 2 W is greater than 1 W. If a difference between the required power and the measured power is greater than the threshold value, the reception power measurement result **34** (=1) has the same meaning as a Foreign Object Detection (FOD) declaration (described below) because it means that foreign objects have been detected. For example, if the reception power measurement result **34** continues to be 1 without change for a specific time, the wireless power transmission apparatus **10** can stop or suspend the transmission of wireless power because it means that foreign objects continue to be present.

In yet another embodiment, if there is a difference between required power and measured power, this has the same meaning as the FOD declaration. In this case, the power measurement unit **31** can provide the control unit **16** with the reception power measurement result **34** indicative of the FOD declaration. If there is no difference between required power and measured power, the power measurement unit **31** may not provide any signal to the control unit **16**.

The control unit **16** receives the reception power measurement result **34**. If it is determined that a significant parasitic load is present near the wireless power transmission apparatus **10** based on the reception power measurement result **34**, the control unit **16** can enter a suspending mode in which the driving of the primary coil **12** is decreased or stopped so that the generation of the parasitic load is prevented. Accordingly, the supply of inefficient induction power can be limited or stopped. That is, the wireless power transmission apparatus **10** takes an action against the detection of foreign objects. Or, the power measurement unit **31** can enter a suspending mode in which the driving of the primary coil **12** is decreased or stopped in order to prevent the generation of the parasitic load. That is, the wireless power reception apparatus **30** takes an action against the detection of foreign objects.

As described above, the present invention provides unidirectional power control technology in which the wireless power reception apparatus **30** sends a signal to the wireless power transmission apparatus **10** and the additional power measurement unit **31** also measures power transmitted by the wireless power transmission apparatus **10**, compares the measured power with required power, and provides a result of the comparison to the wireless power transmission apparatus **10**.

FIG. **2** illustrates an example of a method by which the wireless power reception apparatus **30** using the present invention detects foreign objects.

Referring to FIG. **2**, the wireless power reception apparatus **30** generates the required power information indicative of power requested by the wireless power reception apparatus **30** at step S**200**.

The wireless power reception apparatus **30** sends the required power information to the wireless power transmission apparatus **10** at step S**205**. When the primary coil **12** of the wireless power transmission apparatus **10** generates the required power in response to the required power information, the wireless power reception apparatus **30** receives wireless power based on magnetic induction or magnetic resonance from the wireless power transmission apparatus **10** using the secondary coil **32** at step S**210**.

The wireless power reception apparatus **30** measures wireless power received in response to the required power information at step S**215**. Here, the measured power can be calculated based on a difference between initial wireless power (or the required power), transferred from the wireless power transmission apparatus **10** to the wireless power reception apparatus **30**, and other losses due to foreign objects, such as a nearby parasitic load.

The wireless power reception apparatus **30** provides the wireless power transmission apparatus **10** with a reception power measurement result that reports a result of comparison and analysis for the required power and the measured power at step S**215**.

In an embodiment, the wireless power reception apparatus **30** can indicate a difference between the required power and the measured power as the reception power measurement result **34**.

In another embodiment, the wireless power reception apparatus **30** can indicate the measured power value itself as the reception power measurement result **34**.

In yet another embodiment, the wireless power reception apparatus **30** can indicate a flag form (0 or 1), indicating whether or not there is a difference between the required power and the measured power, as the reception power measurement result.

In yet another embodiment, the wireless power reception apparatus **30** can determine whether a difference between the required power and the measured power is greater than or equal to or smaller than a threshold value and indicate a result of the determination as the reception power measurement result **34**.

In yet another embodiment, if there is a difference between the required power and the measured power, the wireless power reception apparatus **30** can provide the wireless power transmission apparatus **10** with the reception power measurement result **34** indicating the difference. If there is no difference between the required power and the measured power, the wireless power reception apparatus **30** may not provide the reception power measurement result **34** to the wireless power transmission apparatus **10**. In this case, the step S**220** may not occur.

In yet another embodiment, the wireless power reception apparatus **30** can determine whether the measured power is greater than or smaller than the required power and indicate a result of the determination as the reception power measurement result **34**. For example, the reception power measurement result can be indicated by 'high' or 'low'. Here, 'high' indicates that the measured power is greater than the required power, and 'low' indicates that the measured power is smaller than the required power. Or, the reception power measurement result may be indicated by one of three states, including 'high', 'low', and 'equal'.

FIG. **3** illustrates an example of a method by which the wireless power transmission apparatus **10** using the present invention detects foreign objects.

Referring to FIG. **3**, the wireless power transmission apparatus **10** receives the required power information **33** from the wireless power reception apparatus **30** at step S**300**.

The wireless power transmission apparatus **10** sends wireless power to the wireless power reception apparatus **30** in accordance with a magnetic induction or magnetic resonance method in response to required power indicated by the required power information **33** at step S**305**.

The wireless power transmission apparatus **10** receives the reception power measurement result **34**, reporting an actual measurement result of the wireless power transmitted in response to the required power by the wireless power reception apparatus **30**, from the wireless power reception apparatus **30** at step S**310**.

If it is determined that foreign objects have been detected as a result of analyzing the reception power measurement result **34**, the wireless power transmission apparatus **10** enters the suspending mode in which the driving of the primary coil **12** is decreased or stopped. Accordingly, the generation of heat from a parasitic load can be prevented, and the supply of inefficient induction power can be limited or stopped.

FIG. **4** illustrates another example of a method by which the wireless power transmission apparatus **10** using the present invention detects foreign objects.

Referring to FIG. **4**, the steps S**400** to S**410** are the same as the respective steps S**300** to S**310** of FIG. **3**, and thus a detailed description thereof is omitted. Meanwhile, the step S**410** can be limited by the following various embodiments.

For example, in an embodiment in which the reception power measurement result indicates whether the measured power is greater than ('high') or smaller than ('low') the required power, the wireless power transmission apparatus **10** determines whether or not the reception power measurement result **34** indicating 'low' or 'high' has been received N times identically and continuously at step S**415**. Here, N indicates the number of times of continuous reception of 'low' or 'high' that is necessary for the wireless power transmission apparatus **10** to stop the transmission of wireless power, and N can be 2 (i.e., N=2). For example, if the reception power measurement result indicating 'low' has been continuously received twice, the wireless power transmission apparatus **10** can stop the transmission of the wireless power as a measure against the detection of foreign objects at step S**420**. In contrast, if the reception power measurement result indicating 'high' has been continuously received twice, the wireless power transmission apparatus **10** can stop the transmission of the wireless power as a measure against the detection of foreign objects at step S**420**.

In contrast, if the reception power measurement result indicating 'low' or 'high' has been continuously received less than two times, the wireless power transmission apparatus **10** sends the wireless power to the wireless power reception apparatus **30** again at step S**405**. For example, if the reception power measurement result previously indicating 'low' was received, but the reception power measurement result now indicating 'high' is received, the wireless power transmission apparatus **10** does not stop the transmission of the wireless power because the same reception power measurement result does not continue to be received.

For another example, in an embodiment in which the reception power measurement result **34** indicates that there is a difference between the required power and the measured power, if the wireless power transmission apparatus **10** continues to receive the reception power measurement result indicative of 'present difference' N times, the wireless power transmission apparatus **10** can stop the transmission of the wireless power as a measure against the detection of foreign objects at step S**420**.

For yet another example, in an embodiment in which the reception power measurement result **34** indicates that a difference between the required power and the measured power is greater than or equal to or smaller than the threshold value, if the wireless power transmission apparatus **10** continues to receive the reception power measurement result **34** indicative of 'great' or 'small' N times, the wireless power transmission apparatus **10** can stop the transmission of the wireless power as a measure against the detection of foreign objects at step S**420**.

FIG. **5** illustrates the elements of a wireless power transmission system in accordance with another example of the present invention.

Referring to FIG. **5**, the wireless power transmission system **4** includes a wireless power transmission apparatus **40** and at least one wireless power reception apparatus **50**. The wireless power transmission apparatus **40** includes a primary coil **44** and an electricity driving unit **43** coupled with the primary coil **44** and configured to supply electricity driving signals to the primary coil **44** in order to generate an electromagnetic field. A control unit **42** is coupled with the electricity driving unit **43**. The control unit **42** generates a control signal **45**. The electricity driving unit **43** receives the control signal **45** and converts the received control signal **45** into an AC signal in the primary coil **44** in order to generate an induction or resonance magnetic field near the primary coil **44**.

The wireless power transmission apparatus **40** can have a specific and proper form, and an exemplary form of the wireless power transmission apparatus **40** is a platform having a power transmission surface. The wireless power reception apparatus **50** can be placed on or near the platform.

The wireless power reception apparatus **50** can be separate from the wireless power transmission apparatus **40**. The wireless power reception apparatus **50** includes a secondary coil **52** coupled with an electromagnetic field generated from the wireless power transmission apparatus **40** when the wireless power reception apparatus **50** is placed near the wireless power transmission apparatus **40**. In this method, electric power can be transmitted from the wireless power transmission apparatus **40** to the wireless power reception apparatus **50** without a direct electrical contact.

The primary coil **44** and the secondary coil **52** can have specific and proper forms. Each of the primary coil **44** and the secondary coil **52** can be a copper wire on which high permeable magnetic materials, such as ferrite or amorphous metal, are surrounded. The secondary coil **52** may have a single core form or a dual coil form. Or, the secondary coil **52** may include two or more coils.

The wireless power reception apparatus **50** of the wireless power transmission system **4** of FIG. **5** further includes a power measurement unit **51** coupled with the secondary coil **52**.

The power measurement unit **51** generates required power information **53** requested by the wireless power reception apparatus **50** and sends the required power information **53** to the control unit **42**. The required power information **53** is control information for controlling power to be supplied to the wireless power reception apparatus **50**.

For example, the required power information **53** can numerically indicate the amount of power necessary for the wireless power reception apparatus **50**. For example, if the wireless power reception apparatus **50** requires power of 10 W, the power measurement unit **51** can generate the required power information **53** indicating 10 W.

The control unit **42** checks the required power information **53** and generates the control signal **45** so that power indicated by the required power information **53** is generated. For example, when the required power information **53** indicates 10 W, the control unit **42** generates the control signal **45** so that power of 10 W is transmitted. The electricity driving unit **43** receives the control signal **45** and converts the received control signal **45** into an AC signal in the primary coil **44** in order to generate an induction or resonance magnetic field near the primary coil **44**.

The wireless power transmission apparatus **40** further includes a primary power measurement unit **41**. The primary power measurement unit **41** measures power generated from the primary coil **44** in response to the AC signal. For example, the required power information **53** indicates 10 W, but actually generated power can be measured as 12 W. That is, in order for power, actually received by the wireless power reception apparatus **50**, to become 10 W in response to the indication of the required power information **53**, the primary coil **44** generates power of 12 W higher than power of 10 W. This is because power of 2 W has been lost due to foreign objects attributable to a parasitic load near the wireless power transmission system **4** in a process of the wireless power being transmitted from the primary coil **44** to the secondary coil **52**.

The control unit **42** configures or generates a generated power measurement report **54** indicative of generation power measured by the primary power measurement unit **41** and sends the generated power measurement report **54** to the power measurement unit **51**. As described above, the wireless power transmission system **4** supports a bidirectional communication method by which the control information **53** may be transmitted along a path from the wireless power reception apparatus **50** to the wireless power transmission apparatus **40** and the pieces of control information **54** and **55** may be transmitted along a path from the wireless power transmission apparatus **40** to the wireless power reception apparatus **50**.

The power measurement unit **51** compares the required power with indicated power indicated by the generated power measurement report **54**, analyzes a difference between the required power and the indicated power, and determines whether or not to make an FOD declaration based on a result of the analysis.

In an embodiment, the power measurement unit **51** can determine whether a difference between the required power and the indicated power indicated by the generated power measurement report **54** is greater than or equal to or smaller than a threshold value and indicate a result of the determination as a reception power measurement result **55**. For example, if a difference between the required power and the indicated power indicated by the generated power measurement report **54** is greater than the threshold value, the power measurement unit **51** can set the reception power measurement result **55** to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report **54** is smaller than or equal to the threshold value, the power measurement unit **51** can set the reception power measurement result **55** to 0. Or, if a difference between the required power and the indicated power indicated by the generated power measurement report **54** is greater than or equal to the threshold value, the power measurement unit **51** may set the reception power measurement result **55** to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report **54** is smaller than the threshold value, the power measurement unit **51** may set the reception power measurement result **55** to 0. In this case, the subjects indicated by the values 0 and 1 of the reception power measurement result **55** may be changed.

For example, it is assumed that the threshold value is 1 W. If, as in the above example, the indicated power indicated by the generated power measurement report **54** is 12 W and the required power is 10 W, a difference between the indicated power and the required power is 2 W, which is greater than the threshold value of 1 W. In this case, the reception power measurement result **55** indicates 1. If a difference between the required power and the indicated power indicated by the generated power measurement report **54** is greater than the threshold value, it may mean that foreign objects have been detected.

An embodiment in which the power measurement unit **51** compares required power with indicated power indicated by the generated power measurement report **54** and analyzes a difference between the required power and the indicated power in order to make an FOD declaration has been described above. However, the power measurement unit **51** may compare power, actually received by the wireless power reception apparatus **50**, with indicated power indicated by the generated power measurement report **54**, analyze a difference between the actually received power and the indicated power, and make an FOD declaration based on a result of the analysis. Here, a method for the comparison and analysis can be performed like the method of comparing required power with indicated power indicated by the generated power measurement report **54** and analyzing a difference between the required power and the indicated power.

If the wireless power transmission apparatus **40** sends wireless power greater than required power (or power actually received by the wireless power reception apparatus **50**) by a certain amount or higher or excessive wireless power owing to a loss due to foreign objects and thus the transmitted wireless power satisfies the required power, an FOD declaration is made in order to stop or suspend the transmission of the wireless power because wireless power efficiency can be deteriorated. In this sense, the reception power measurement result **55** (=1) may have the same meaning as the FOD declaration. For example, if the reception power measurement result **55** (=1) continues to remain intact for a specific time, it means that foreign objects continue to be present and the wireless power transmission apparatus **40** can stop or suspend the transmission of wireless power.

The control unit **42** receives the reception power measurement result **55**. If it is determined that a significant parasitic load is present near the wireless power transmission apparatus **40** based on the reception power measurement result **55**, the control unit **42** can enter a suspending mode in which the driving of the primary coil **44** is decreased or stopped in order to prevent the generation of the parasitic load. Accordingly, the supply of inefficient induction power can be limited or stopped. That is, the wireless power transmission apparatus **40** takes an action against the detection of foreign objects. Or, the power measurement unit **51** may enter a suspending mode in which the driving of the primary coil **44** is decreased or stopped in order to prevent the generation of heat from a parasitic load. That is, the wireless power reception apparatus **50** takes an action against the detection of foreign objects.

As described above, the present invention provides bidirectional power control technology in which the wireless power transmission apparatus **40** sends wireless power to the wireless power reception apparatus **50** and the control unit **42** also sends the generated power measurement report **54**, indicating power generated from or transmitted by the wireless power transmission apparatus **40**, to the wireless power reception apparatus **50**.

FIG. **6** illustrates the elements of a wireless power transmission system in accordance with yet another example of the present invention.

Referring to FIG. **6**, a wireless power transmission apparatus **60** has the same elements as the wireless power transmission apparatus **10** of FIG. **1**. Meanwhile, a wireless power reception apparatus **70** has the same elements as the wireless power reception apparatus **30** of FIG. **1** except that it further includes a measurement coil **71**. The power measurement unit **31** is coupled with the measurement coil **71**. The measurement coil **71** may be provided in such a way as to surround the outside of the secondary coil **52** or may be provided within the secondary coil **52** in such a way as to surround the inside of the secondary coil **52**.

When a magnetic field or a current or voltage is primarily induced in the secondary coil **52** by means of magnetic induction or magnetic resonance between the primary coil **12** and the secondary coil **52**, a magnetic field or a current or voltage is secondarily induced in the measurement coil **71**. The power measurement unit **31** can measure received wireless power using the magnetic field or a current or voltage secondarily induced in the measurement coil **71**.

FIG. **6** illustrates an example in which the measurement coil **71** is further added to the wireless power reception apparatus **30** of FIG. **1**, but the measurement coil **71** may be likewise included in the wireless power reception apparatus **50** of FIG. **5**.

FIG. **7** illustrates another example of a method by which the wireless power reception apparatus **50** using the present invention detects foreign objects.

Referring to FIG. **7**, the wireless power reception apparatus generates the required power information indicative of required power requested by the wireless power reception apparatus at step S**700**.

The wireless power reception apparatus sends the required power information to the wireless power transmission apparatus at step S**705**. When the wireless power transmission apparatus generates power in response to the required power information, the wireless power reception apparatus receives wireless power based on magnetic induction or resonant induction from the wireless power transmission apparatus at step S**710**.

The wireless power reception apparatus receives the generated power measurement report, which measures (or indicates) the power generated from the wireless power transmission apparatus **40**, from the wireless power transmission apparatus at step S**715**. Here, the power generated from the wireless power transmission apparatus does not include a loss attributable to foreign objects and may differ from wireless power actually received by the wireless power reception apparatus. For example, if a loss attributable to foreign objects is included in the power generated from the wireless power transmission apparatus, the wireless power actually received by the wireless power reception apparatus can be measured as being lower than the generated power.

The wireless power reception apparatus compares the required power (or actually received power) with the indicated power indicated by the generated power measurement report, analyzes a result of the comparison, and determines whether or not to make an FOD declaration based on a result of the analysis at step S**720**.

In an embodiment, the wireless power reception apparatus can determine whether a difference between the required power and the indicated power indicated by the generated power measurement report is greater than or equal to or smaller than a threshold value and indicate a result of the determination as the reception power measurement result. For example, if a difference between the required power and the indicated power indicated by the generated power measurement report is greater than the threshold value, the wireless power reception apparatus can set the reception power measurement result to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is smaller than or equal to the threshold value, the wireless power reception apparatus can set the reception power measurement result to 0. Or, if a difference between the required power and the indicated power indicated by the generated power measurement report is greater than or equal to the threshold value, the wireless power reception apparatus may set the reception power measurement result to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is smaller than the threshold value, the wireless power reception apparatus may set the reception power measurement result to 0. The subjects indicated by the values 0 and 1 of the reception power measurement result may be changed.

For example, it is assumed that the threshold value is 1 W. If, as in the above example, the indicated power indicated by the generated power measurement report is 12 W and the required power is 10 W, a difference between the indicated power and the required power is 2 W, which is greater than the threshold value of 1 W. In this case, the reception power measurement result indicates 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is greater than the threshold value, it may mean that foreign objects have been detected.

The wireless power reception apparatus sends the reception power measurement result, reporting a result of the comparison and analysis, to the wireless power transmission apparatus at step S**725**.

FIG. **8** illustrates another example of a method by which the wireless power transmission apparatus using the present invention detects foreign objects.

Referring to FIG. **8**, the wireless power transmission apparatus receives the required power information from the wireless power reception apparatus at step S**800**. The wireless power transmission apparatus generates wireless power based on magnetic induction in response to required power indicated by the required power information. That is, the wireless power transmission apparatus checks the required power information and generates the control signal so that the power indicated by the required power information is induced. For example, when the required power information indicates 10 W, the wireless power transmission apparatus generates the control signal so that power of 10 W is transmitted. The electricity driving unit receives the control signal and converts the received control signal into an AC signal in the primary coil in order to generate an induction electromagnetic field near the primary coil.

The wireless power transmission apparatus sends the generated wireless power to the wireless power reception apparatus at step S**805**.

At this time, the wireless power transmission apparatus measures power generated from the primary coil in response to the AC signal at step S**810**. For example, the required power information indicates 10 W, but actually generated power may be measured as being 12 W. That is, in order to transfer the power of 10 W to the wireless power reception apparatus in response to the indication of the required power information, the primary coil generates power of 12 W higher than the power of 10 W. This is because power of 2 W has been lost due to foreign objects attributable to a parasitic load in a process of the wireless power being transmitted from the primary coil to the secondary coil.

The wireless power transmission apparatus configures the generated power measurement report indicating the measured generation power and sends the configured generated power measurement report to the wireless power reception apparatus at step S**815**. As described above, a bidirectional communication method by which control information may be transmitted along a path from the wireless power transmission apparatus to the wireless power reception apparatus and the control information may be transmitted along a path from the wireless power reception apparatus to the wireless power transmission apparatus is made possible.

The wireless power transmission apparatus receives the reception power measurement result, that is, a result of comparison and analysis for the required power (or actually received power) and the indicated power indicated by the generated power measurement report, from the wireless power reception apparatus at step S**820**.

The reception power measurement result is information indicating whether a difference between the required power and the indicated power indicated by the generated power measurement report is greater than or equal to or smaller than a threshold value. For example, if a difference between the required power and the indicated power indicated by the generated power measurement report is greater than the threshold value, the secondary reception power measurement result can be set to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is smaller than or equal to the threshold value, the reception power measurement result can be set to 0. In contrast, if a difference between the required power and the indicated power indicated by the generated power measurement report is greater than or equal to the threshold value, the reception power measurement result may be set to 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is smaller than the threshold value, the reception power measurement result may be set to 0. The subjects indicated by the values 0 and 1 of the reception power measurement result may be changed.

For example, it is assumed that the threshold value is 1 W. If, as in the above example, the indicated power indicated by the generated power measurement report is 12 W and the required power is 10 W, a difference between the indicated power and the required power is 2 W, which is greater than the threshold value of 1 W. In this case, the reception power measurement result indicates 1. If a difference between the required power and the indicated power indicated by the generated power measurement report is greater than the threshold value, it may mean that foreign objects have been detected. Accordingly, the wireless power transmission apparatus **40** can recognize this as an FOD declaration.

If it is determined that foreign objects have been detected as a result of analyzing the reception power measurement result, the wireless power transmission apparatus takes an action against the detection of the foreign objects at step S**825**. For example, the wireless power transmission apparatus can enter a suspending mode in which the driving of the primary coil **12** is decreased or stopped. Accordingly, the generation of heat from a parasitic load can be prevented, and the supply of inefficient induction power can be limited or stopped.

FIG. **9** is a flowchart illustrating the operation of the wireless power transmission apparatus and the wireless power reception apparatus using the present invention.

Referring to FIG. **9**, the wireless power reception apparatus generates the required power information indicative of power requested by the wireless power reception apparatus at step S**900**.

The wireless power reception apparatus sends the required power information to the wireless power transmission apparatus at step S**905**. When the primary coil of the wireless power transmission apparatus generates the required power in response to the required power information, the secondary coil of the wireless power reception apparatus receives wireless power based on magnetic induction or magnetic resonance from the wireless power transmission apparatus at step S**910**.

The wireless power reception apparatus measures wireless power received in response to the required power information at step S**915**. The power measurement unit may measure wireless power induced in the secondary coil or may measure wireless power secondarily induced from the secondary coil to the measurement coil. Here, the measured power can be calculated based on a difference between initial wireless power (or required power), transferred from the wireless power transmission apparatus to the wireless power reception apparatus, and a loss attributable to foreign objects, such as a parasitic load that is present nearby.

The wireless power reception apparatus provides the wireless power transmission apparatus with the reception power measurement result that reports a result of comparison and analysis for the required power and the measured power ate step S**920**.

In an embodiment, the reception power measurement result can be defined as a difference between the required power and the measured power.

In another embodiment, the reception power measurement result can be defined as the measured power itself.

In yet another embodiment, the reception power measurement result may be defined in the form of a flag (0 or 1) indicating whether or not there is a difference between the required power and the measured power.

In further yet another embodiment, the reception power measurement result can be defined as a result indicating whether a difference between the required power and the measured power is greater than or equal to or smaller than a threshold value.

In further yet another embodiment, the reception power measurement result can be defined as information that is transmitted to the wireless power transmission apparatus only when there is a difference between the required power and the measured power. That is, if there is no difference between the required power and the measured power, the reception power measurement result is not transmitted to the wireless power transmission apparatus. In this case, the step S**920** may be omitted.

In further yet another embodiment, the reception power measurement result can be defined as a result indicating whether the measured power is greater than or smaller than the required power. For example, the reception power measurement result can be indicated by 'high' or 'low'. Here, 'high' indicates that the measured power is greater than the required power, and 'low' indicates that the measured power is smaller than the required power. Or, the reception power measurement result may be indicated by any one of three states, including 'high', 'low', and 'equal'.

If it is determined that foreign objects have been detected as a result of analyzing the reception power measurement result, the wireless power transmission apparatus takes an action against the detection of the foreign objects at step S**925**. For example, the wireless power transmission apparatus enters a suspending mode in which the driving of the primary coil is decreased or stopped. Accordingly, the generation of heat from a parasitic load can be prevented, and the supply of inefficient induction power can be limited or stopped.

The action taken by the wireless power transmission apparatus against the detection of foreign objects can include the following embodiments. For example, in an embodiment in which the reception power measurement result indicates whether the measured power is greater than ('high') or smaller than ('low') the required power, the wireless power transmission apparatus determines whether or not the reception power measurement result indicating 'low' or 'high' has been received identically and continuously N times. Here, N indicates the number of times of continuous reception of 'low' or 'high' that is necessary for the wireless power transmission apparatus to stop the transmission of wireless power, and N can be 2 (N=2). For example, if the reception power measurement result indicating 'low' has been continuously received twice, the wireless power transmission apparatus can stop the transmission of wireless power as a measure against the detection of foreign objects. In contrast, if the reception power measurement result indicating 'high' has been continuously received twice, the wireless power transmission apparatus can stop the transmission of the wireless power as a measure against the detection of foreign objects.

In contrast, if the reception power measurement result indicating 'low' or 'high' has been continuously received less than two times, the wireless power transmission apparatus determines that foreign objects have not been detected and thus can send the wireless power to the wireless power reception apparatus again. For example, if the reception power measurement result previously indicating 'low' was received, but the reception power measurement result now indicating 'high' is received, the wireless power transmission apparatus does not stop the transmission of the wireless power because the same reception power measurement result does not continue to be received.

For another example, in an embodiment in which the reception power measurement result indicates that there is a difference between the required power and the measured power, if the wireless power transmission apparatus continues to receive the reception power measurement result indicative of 'present difference' N times, the wireless power transmission apparatus can stop the transmission of the wireless power as a measure against the detection of foreign objects.

For yet another example, in an embodiment in which the reception power measurement result indicates that a difference between the required power and the measured power is greater than or equal to or smaller than the threshold value, if the wireless power transmission apparatus continues to receive the reception power measurement result indicative of 'great' or 'small' N times, the wireless power transmission apparatus can stop the transmission of the wireless power as a measure against the detection of foreign objects.

All the functions can be executed by a processor, such as a microprocessor, a controller, a microcontroller, or an Application Specific Integrated Circuit (ASIC) according to software or a program code coded to perform the above functions. It can be said that the design, development, and implementation of the code is evident to those skilled in the art based on the description of the present invention.

In accordance with the present invention, foreign objects intervened between the wireless power transmission apparatus and the wireless power reception apparatus are recognized, and a user removes the foreign objects. Accordingly, damage to a device attributable to foreign objects can be prevented.

Although a few of the embodiments of the present invention have been shown and described above, a person having ordinary skill in the art will appreciate that the present invention can be modified, changed, and implemented in various ways without departing from the principles, spirit and scope of the present invention. Accordingly, the present invention is not limited to the embodiments, and the present invention can be said to include all embodiments within the scope of the claims below and their equivalents.

What is claimed is:

1. A wireless power transmission method of a wireless power transmission apparatus in a wireless power transmission system comprising a power transmission path that is generated by magnetic resonance coupling between a primary coil included in the wireless power transmission apparatus and a secondary coil included in a wireless power reception apparatus, comprising:

receiving first control information using a communication path, wherein the first control information is generated based on a desired power of the wireless power reception apparatus;

generating a wireless power based on the first control information, and transmitting the wireless power to the wireless power reception apparatus using the magnetic resonance coupling;

receiving second control information using the communication path, wherein the second control information is generated based on a wireless power measured by the wireless power reception apparatus; and

controlling the wireless power based on the first control information and the second control information.

2. The wireless power transmission method of claim **1**, wherein the first control information is a numerically indicated power value.

3. The wireless power transmission method of claim **1**, wherein the controlling of the wireless power comprises calculating a lost power based on the first control information and the second control information, and determining that a foreign object is present when the lost power is greater than a threshold value.

4. The wireless power transmission method of claim **3**, wherein when the foreign object is determined to be present, the wireless power transmission apparatus is configured to execute a power suspending mode.

5. A wireless power reception method of a wireless power reception apparatus in a wireless power transmission system comprising a power transmission path that is generated by magnetic resonance coupling between a primary coil included in a wireless power transmission apparatus and a secondary coil included in the wireless power reception apparatus, comprising:

generating first control information based on a desired power of the wireless power reception apparatus;

transmitting the first control information to the wireless power transmission apparatus using a communication path;

receiving a wireless power generated based on the first control information using the magnetic resonance coupling;

measuring an amount of the received wireless power;

generating second control information based on the measured wireless power;

transmitting the second control information to the wireless power transmission apparatus using the communication path; and

receiving a wireless power controlled by the wireless power transmission apparatus based on the first control information and the second control information.

6. The wireless power reception method of claim **5**, wherein the first control information is a numerically indicated power value.

7. The wireless power reception method of claim **5**, wherein the controlling, by the wireless power transmission apparatus, the wireless power comprises calculating a lost power based on the first control information and the second information, and determining that a foreign object is present when the lost power is greater than a threshold value.

8. The wireless power reception method of claim **7**, wherein when the foreign object is determined to be present, the wireless power transmission apparatus is configured to execute a power suspending mode.

9. A wireless power transmission apparatus, comprising:

a primary coil coupled with a secondary coil included in a wireless power reception apparatus and configured to generate magnetic resonance coupling with the secondary coil; and

a control unit configured to receive first control information using a communication path, wherein the first control information is generated based on a desired power of the wireless power reception apparatus,

wherein the primary coil is configured to transmit a wireless power generated based on the first control information to the secondary coil using the magnetic resonance coupling, and

the control unit is configured to receive second control information using the communication path, wherein the second control information is generated based on a wireless power measured by the wireless power reception apparatus, and to control the wireless power based on the first control information and the second control information.

10. The wireless power transmission apparatus of claim **9**, wherein the first control information is a numerically indicated power value.

11. The wireless power transmission apparatus of claim **9**, wherein the control unit is configured to calculate a lost power based on the first control information and the second control information, and to determine that a foreign object is present when the lost power is greater than a threshold value.

12. The wireless power transmission apparatus of claim **11**, wherein when the foreign object is determined to be present, the wireless power transmission apparatus is configured to execute a power suspending mode.

13. A wireless power reception apparatus, comprising:

a secondary coil coupled with a primary coil included in a wireless power transmission apparatus and configured to generate magnetic resonance coupling with the primary coil; and

a measurement unit configured to transmit first control information using a communication method, wherein the first control information is generated based on a desired power of the wireless power reception apparatus,

wherein the secondary coil is configured to receive a wireless power generated based on the first control information using the magnetic resonance coupling, and

the measurement unit is configured to measure an amount of the received wireless power, and to transmit second control information using the communication path, wherein the second control information is generated based on a wireless power measured by the wireless power reception apparatus, so that the wireless power is controlled by the wireless power transmission apparatus based on the first control information and the second control information.

14. The wireless power reception apparatus of claim **13**, wherein the first control information is a numerically indicated power value.

15. The wireless power reception apparatus of claim **13**, wherein the wireless power transmission apparatus is configured to calculate a lost power based on the first control information and the second information, and to determine that a foreign object is present when the lost power is greater than a threshold value.

16. The wireless power reception apparatus of claim **15**, wherein when the foreign object is determined to be present, the wireless power transmission apparatus is configured to execute a power suspending mode.

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